NASA TECH BRIEF

Study Made of Large Amplitude Fuel Sloshing

To obtain a better understanding of fuel sloshing in large liquid boosters, such as the Saturn vehicle, a study was made of resonant oscillations of an ideal fluid in a cylindrical tank. Although a linear theory predicts satisfactory results away from resonance, a nonlinear theory is required at or near resonance. Prior to this study only limited information was available on fluid motions due to forcing frequencies at or near resonance.

The study utilized a perturbation procedure. The velocity potential and wave profile were expanded in one-third powers of the exciting amplitude. The constant pressure condition and the kinematic free surface condition were combined into one equation valid on the free surface. The arbitrary constants which are determined by removing the secular terms from the third order solution contain an additional "depth correction" term. Analytical expressions have been obtained for the wave amplitude, the force and moment on the tank walls, and the displacement of the center of mass for both the planar mode and the nonplanar or rotary slosh mode.

One conclusion of this study has been that the nonlinearities of the system tend to make the liquid in the planar mode behave as a soft spring for large depths and a hard spring for all depths. The quantitative engineering results obtained are curves of wave amplitude, force, moments, and c.g. displacement versus the frequency parameter. These curves are nondimensional and may be adapted to any tank with this geometry.

It is believed that more realistic structural design criteria may be formulated when the dynamic response of the liquid in a cylindrical tank can be predicted analytically.

Note:

Additional details are contained in: *Finite Amplitude Liquid Oscillations II. Forced Resonant Oscillations,* by O. D. DiMaggio and R. N. Salzman, SID 65-853-1, North American Aviation, Inc., June 1966. Copies of this report are available from:

Technology Utilization Officer
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Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D. C. 20546.

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